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**Hosoya et al.**

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(54) **TILT-ANGLE ADJUSTING APPARATUS AND SHIP PROPULSION MACHINE**


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***B63H 21/21*** (2006.01)
***B63H 20/10*** (2006.01)

(52) **U.S. Cl.**
CPC ..................................... ***B63H 20/10*** (2013.01)

(58) **Field of Classification Search**
CPC ........ B63H 20/08; B63H 20/10; B63H 20/14; B63H 25/02
USPC ............................ 440/1, 53, 61 T, 84; 701/21
See application file for complete search history.



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(57) **ABSTRACT**


To provide a technique capable of adjusting a tilt angle of a ship propulsion machine body with respect to a hull to a tilt angle suitable for a travelling state easily and with high accuracy. A motor adjusting a tilt angle of a ship propulsion machine body with respect to a hull and a control device controlling drive of the motor so as to change the tilt angle in accordance with an output from a hull angle sensor detecting a hull angle as an angle of the hull with respect to the water surface are included.


**3 Claims, 9 Drawing Sheets**

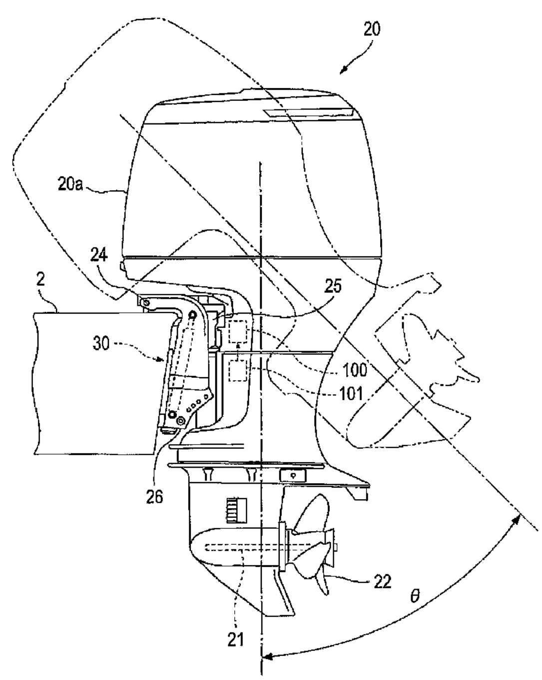


FIG.1A

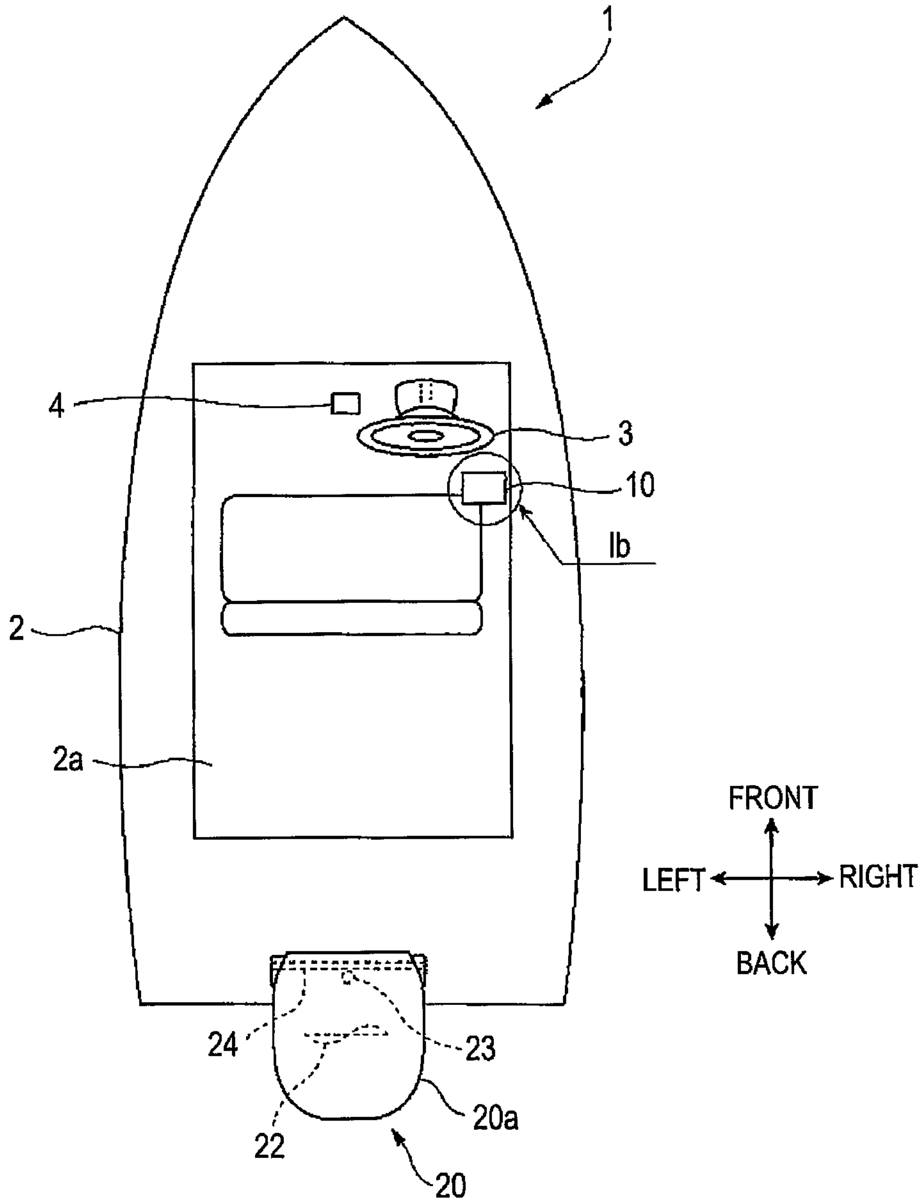

1
4
3
10
Ib
2
2a
FRONT
LEFT
RIGHT
BACK
24
23
20a
22
20

FIG.1B

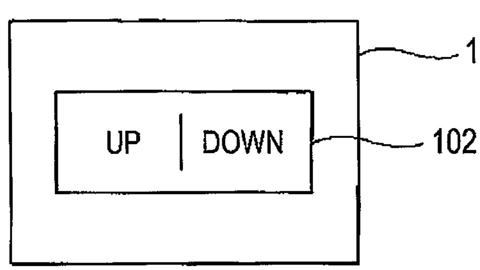

10
UP
DOWN
102

FIG.2

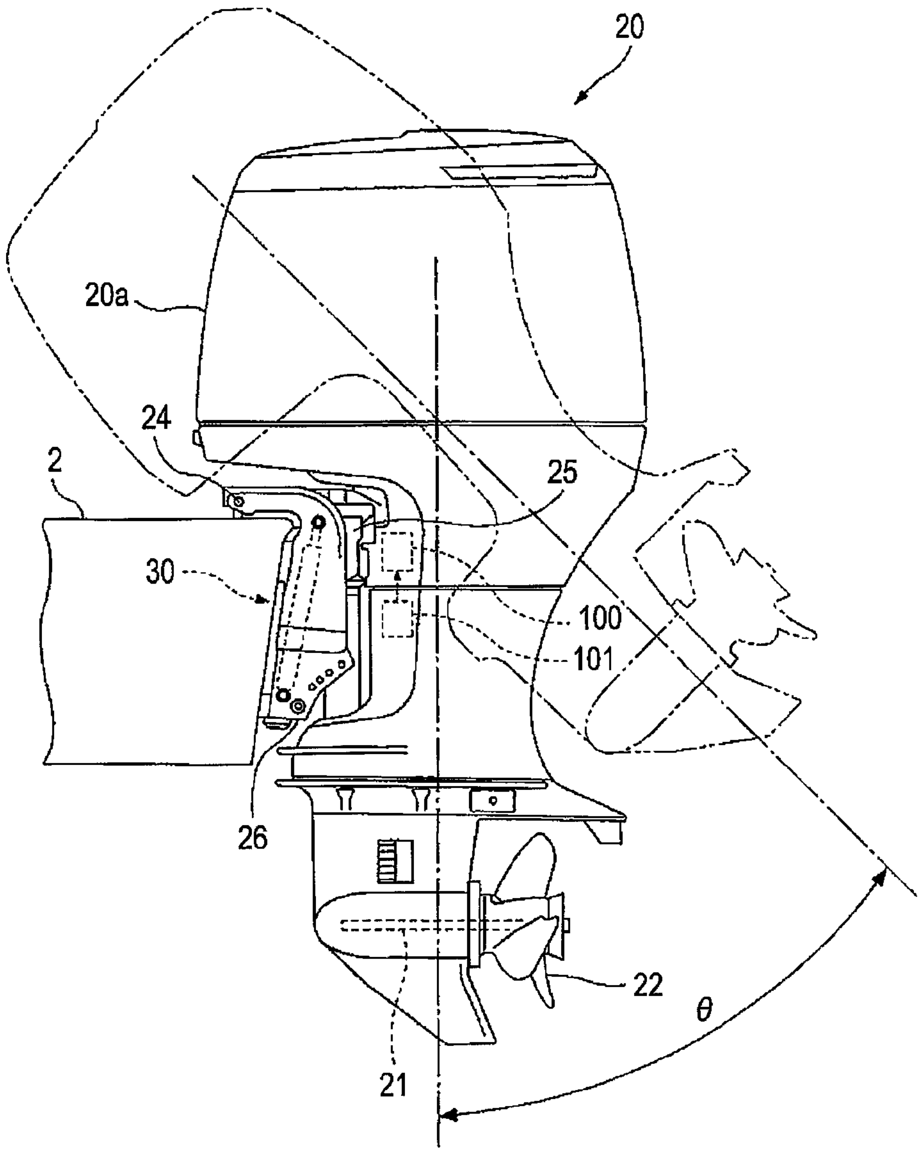


FIG.3

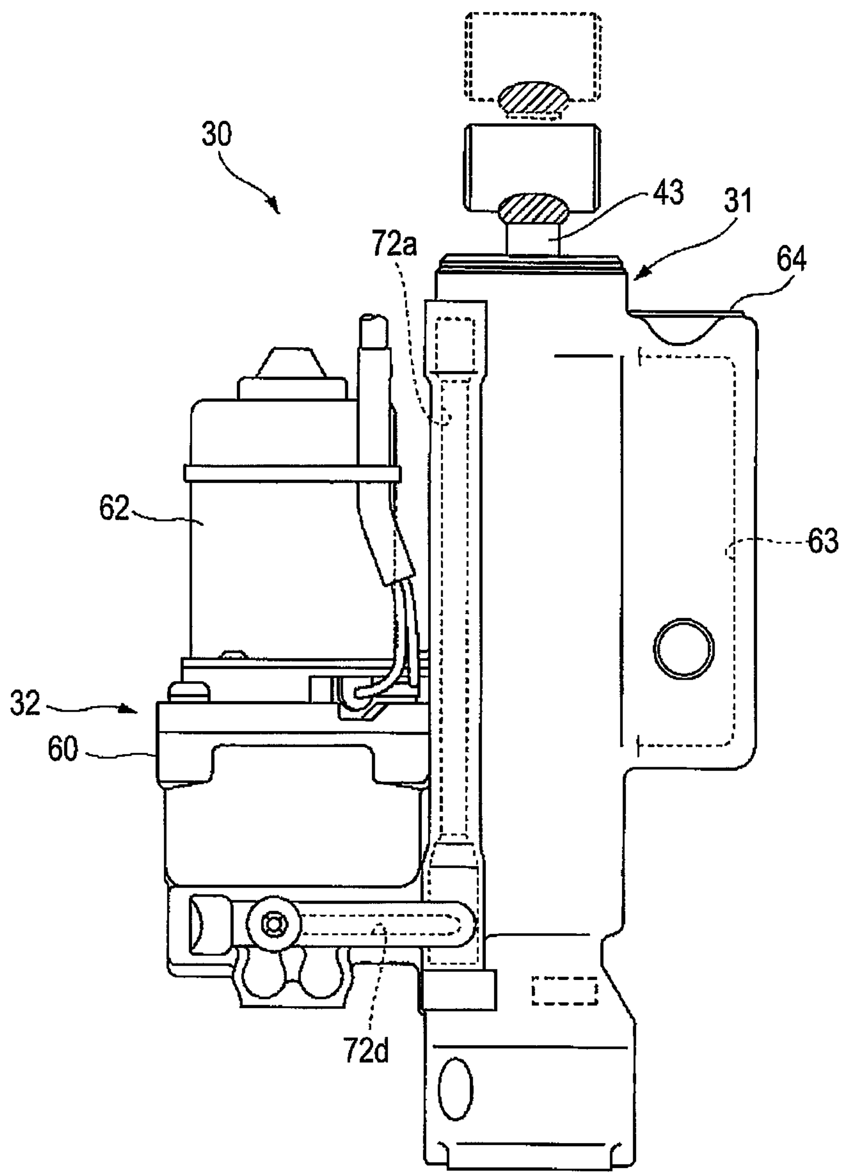


FIG.4

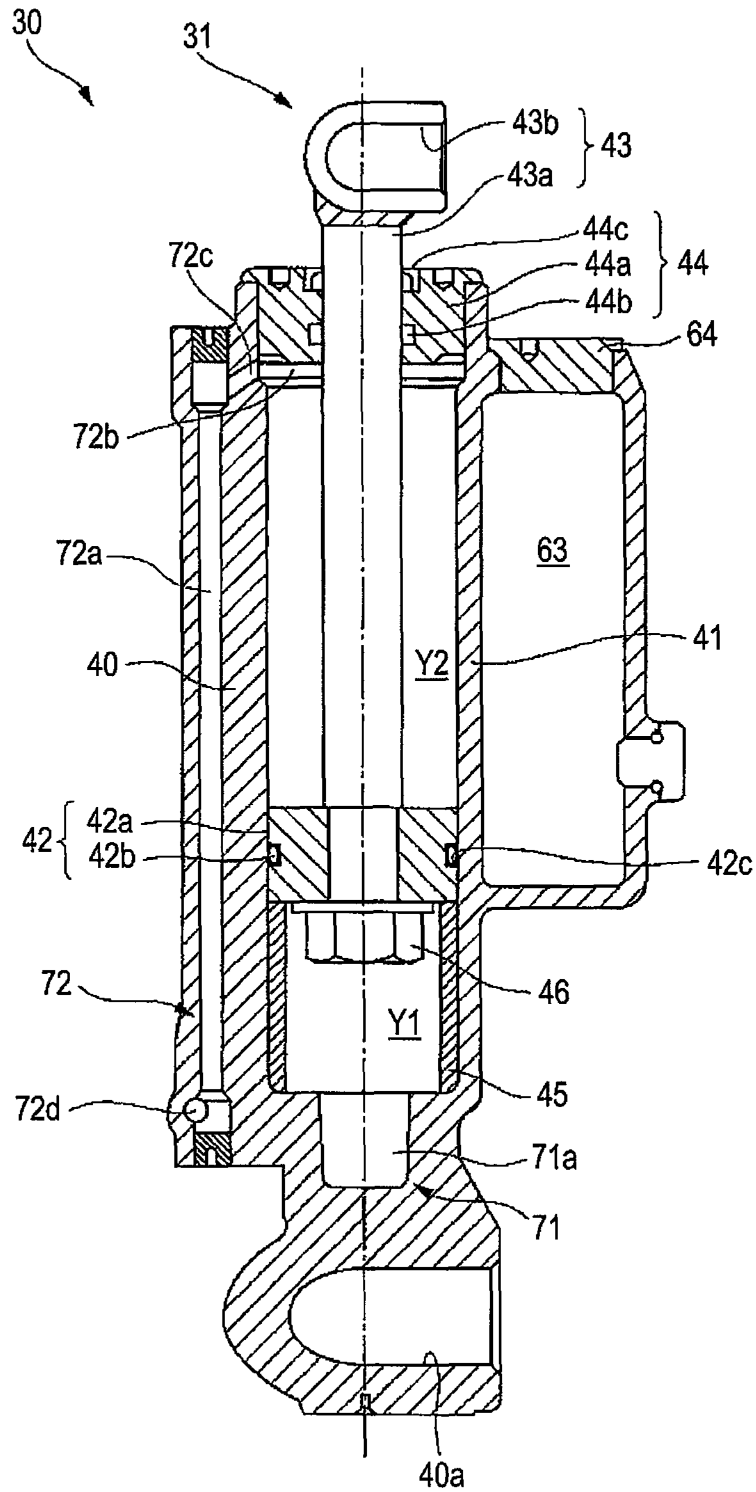

30
31
43b
43
43a
44c
44a
44
44b
72c
64
72b
72a
63
41
40
Y2
42a
42
42b
42c
46
72
Y1
72d
45
71a
71
40a

FIG.5

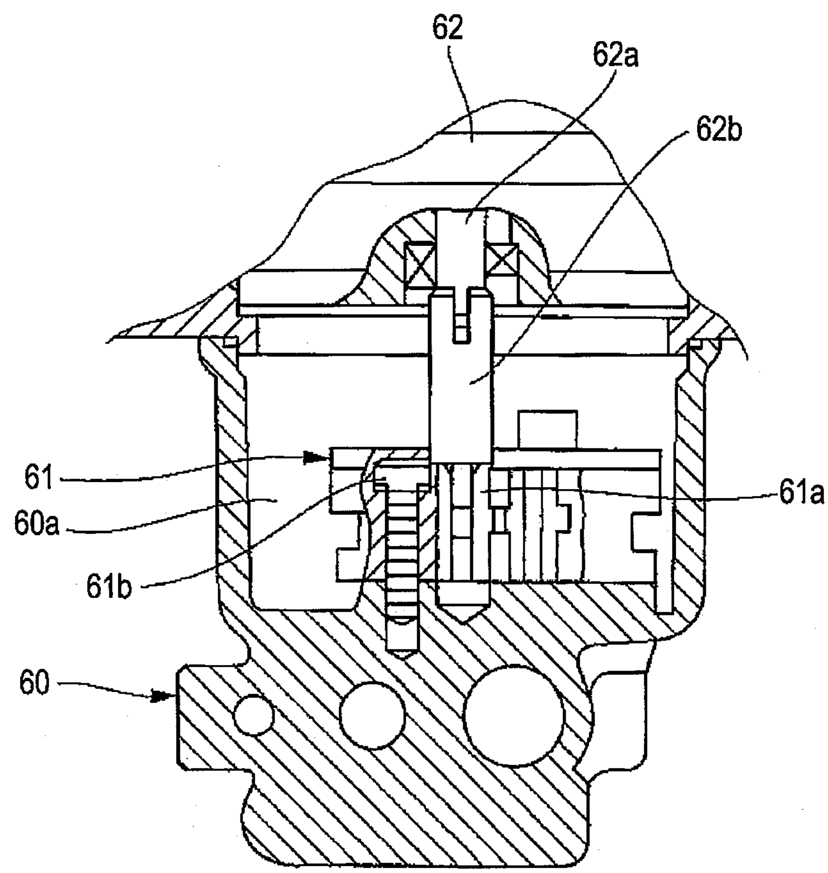


FIG.6

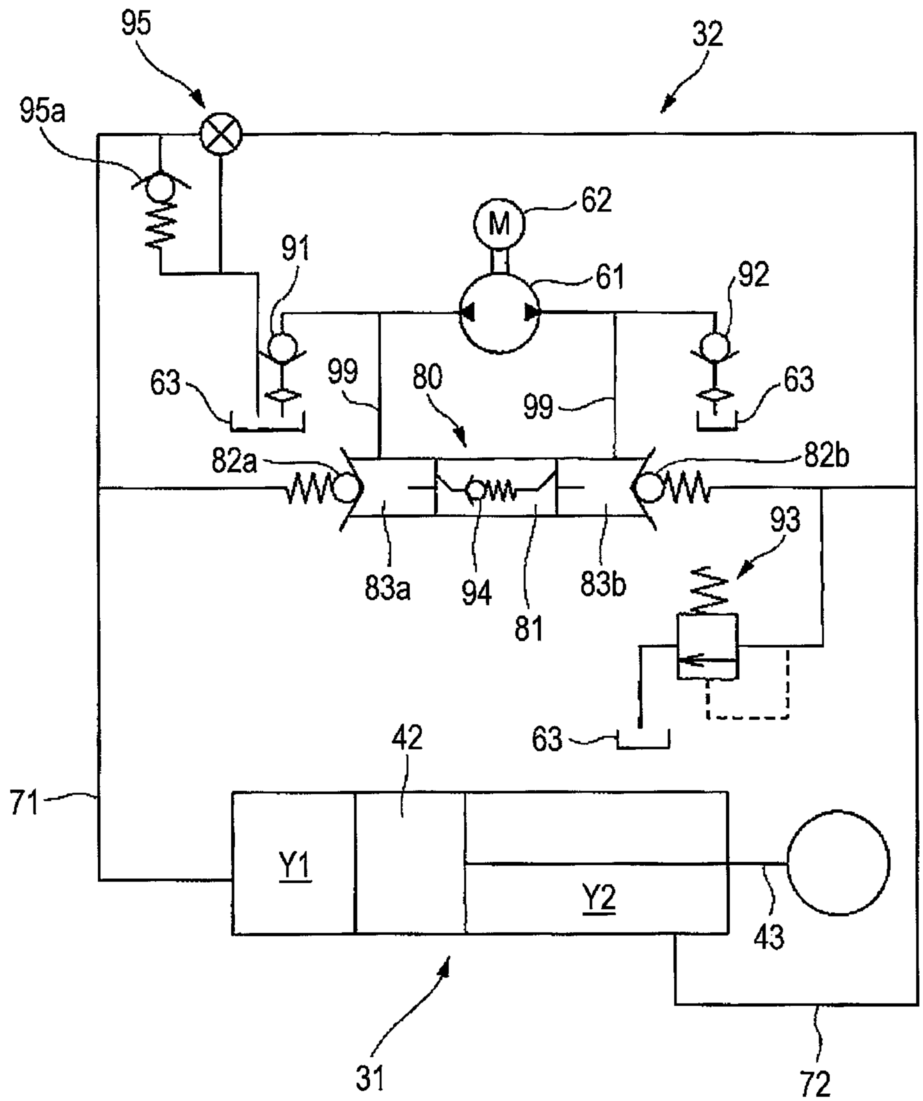

95
32
95a
M
62
61
91
92
63
99
80
99
63
82a
82b
93
83a
94
81
83b
63
42
71
Y1
Y2
43
31
72

FIG.7

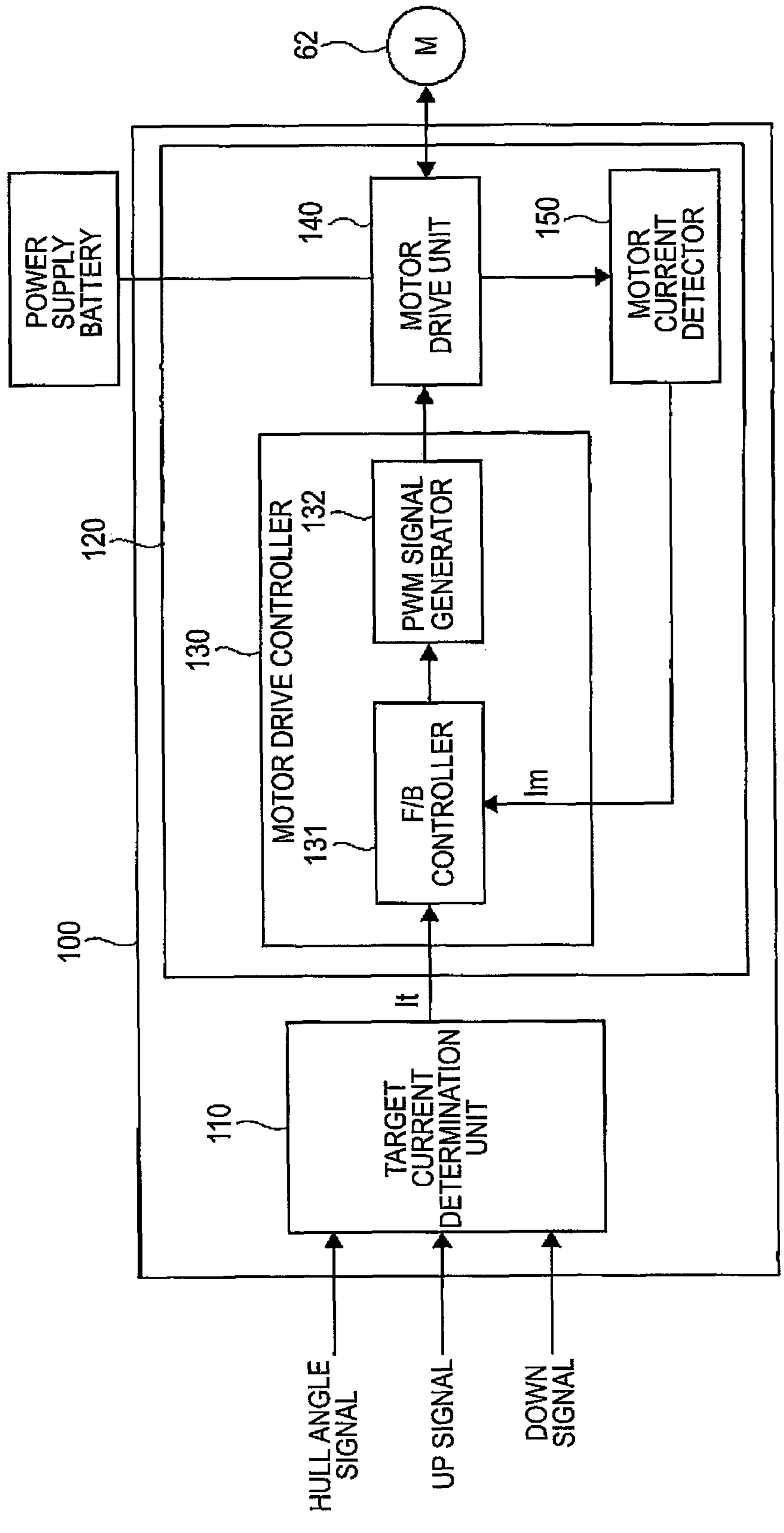

62
M
POWER SUPPLY BATTERY
140
MOTOR DRIVE UNIT
150
MOTOR CURRENT DETECTOR
120
130
MOTOR DRIVE CONTROLLER
132
PWM SIGNAL GENERATOR
131
F/B CONTROLLER
Im
100
It
110
TARGET CURRENT DETERMINATION UNIT
HULL ANGLE SIGNAL
UP SIGNAL
DOWN SIGNAL

*FIG.8A*

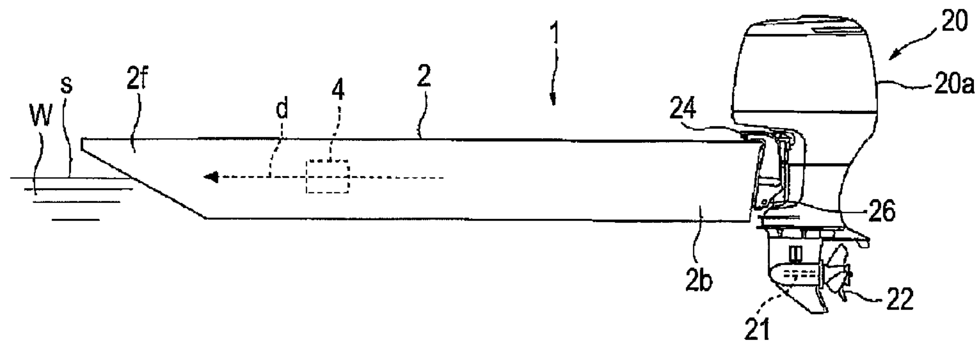



*FIG.8B*

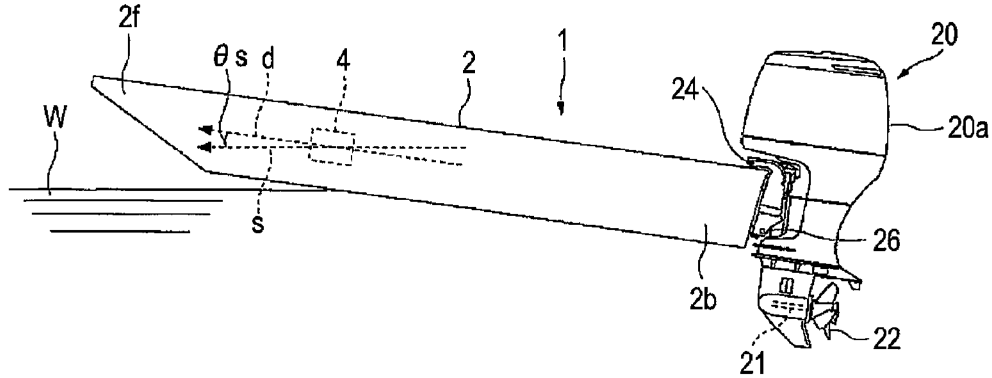



*FIG.8C*

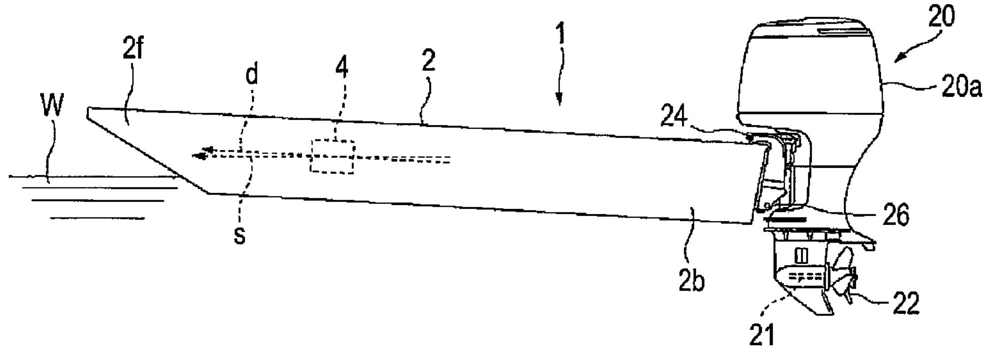
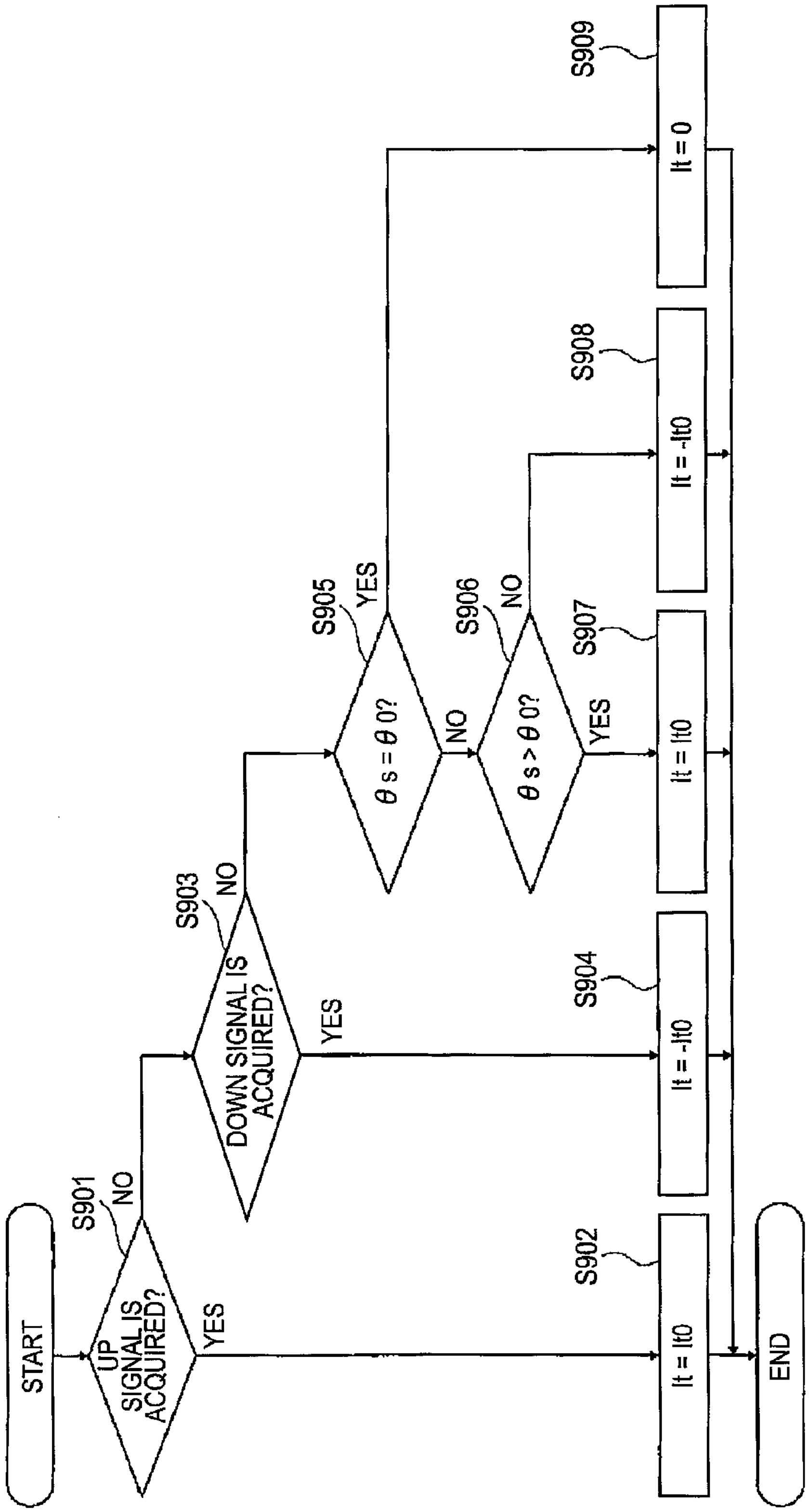


FIG.9


START
S901
UP SIGNAL IS ACQUIRED?
YES
NO
S902
It = It0
S903
DOWN SIGNAL IS ACQUIRED?
YES
NO
S904
It = -It0
S905
θ s = θ 0?
YES
NO
S906
θ s > θ 0?
YES
NO
S907
It = It0
S908
It = -It0
S909
It = 0
END

# TILT-ANGLE ADJUSTING APPARATUS AND SHIP PROPULSION MACHINE

## CROSS-REFERENCE TO RELATED APPLICATIONS

This application is based on and claims priority under 35 U.S.C. 119 from Japanese Patent Application No. 2013-057392 filed on Mar. 19, 2013, the entire content of which is incorporated herein by reference.

## BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a tilt-angle adjusting apparatus and a ship propulsion machine.

2. Description of Background Art

In background art, an apparatus of changing the angle of a ship propulsion machine body with respect to a hull by extending and retracting a cylinder apparatus connected between the hull and the ship propulsion machine body is proposed.

For example, a tilt-trim apparatus described in JP-UM-B-7-32385 (Patent Document 1) is configured as follows. That is, a hydraulic cylinder is installed between a bracket attaching a propulsion unit (ship propulsion machine body) to the ship and the propulsion unit, current-carrying actuation circuits on an "up" side and a "down" side of an electric drive motor are on/off operated to drive a hydraulic pump, and working fluid fed by pressure by the hydraulic pump is supplied to a piston-side oil chamber or a piston-rod side oil chamber of the hydraulic cylinder, thereby extending and retracting the hydraulic cylinder, as a result, the propulsion unit is tilt-trim operated to the "up" side or the "down" side. Then, an operation switch for on/off operating the current-carrying actuation circuits on the "up" side and the "down" side of the drive motor is included, in which an on-state is maintained only while the operation switch is pressed by adding manual operation force to the operation switch and the circuit is turned off when the switch is released.

## SUMMARY OF THE INVENTION

In the structure of adjusting the tilt angle of the ship propulsion machine body with respect to the hull by keeping pressing the operation switch, it is difficult to adjust the tilt angle to a desired angle. It is particularly difficult for a beginner of ship operation to adjust the angle to a desired angle for keeping a travelling posture at the time of high-speed travelling. Accordingly, for example, when an operator keeps pressing a button for increasing the tilt angle to adjust the angle to a desired tilt angle, the angle exceeds the desired tilt angle, then, it is necessary to press a button for decreasing the tilt angle again to adjust the angle to the desired tilt angle. As a result, the electric motor has to be driven uselessly or it is difficult to adjust the tilt angle quickly.

An object of the present invention is to provide an apparatus capable of adjusting the tilt angle of the ship propulsion machine body with respect to the hull to a tilt angle suitable for a travelling state easily and with high accuracy.

In order to achieve the above object, the present invention provides a tilt-angle adjusting apparatus including a motor adjusting a tilt angle of a ship propulsion machine body with respect to a hull and a motor control unit configured to control drive of the motor so as to change the tilt angle in accordance with an output from a detecting unit configured to detect a hull angle as an angle of the hull with respect to the water surface.

Here, the motor control unit may recognize the hull angle based on a signal from the detecting unit provided at the hull and detecting the hull angle and may control drive of the motor so that the recognized hull angle becomes a given angle.

Moreover, the motor control unit may rotate the motor to one rotation direction when the hull angle is larger than the given angle and may rotate the motor to the other rotation direction when the hull angle is smaller than the given angle.

Furthermore, the tilt-angle adjusting apparatus may further include an operating unit to be operated for adjusting the tilt angle, and the motor control unit may control drive of the motor based on a signal outputted from the operating unit in the case where the operating unit is operated even when the hull angle is different from the given angle.

According to another aspect of the invention, there is provided a ship propulsion machine giving propulsion to a hull including a ship propulsion machine body including a propeller, and a tilt-angle adjusting apparatus having a motor adjusting a tilt angle of the ship propulsion machine body with respect to the hull, and a motor control unit configured to control drive of the motor so as to change the tilt angle in accordance with a hull angle as an angle of the hull with respect to the water surface.

According to an embodiment of the invention, it is possible to adjust the tilt angle of the ship propulsion machine body with respect to the hull to a tilt angle suitable for a travelling state easily and with high accuracy.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1**A and **1**B are schematic structure views of a ship according to an embodiment;

FIG. **2** is a schematic structure view of a ship propulsion machine;

FIG. **3** is an outline view of a tilt-angle adjusting apparatus;

FIG. **4** is a cross-sectional view of a cylinder apparatus and a pump chamber;

FIG. **5** is a cross-sectional view of a motor support portion;

FIG. **6** is a schematic diagram showing the arrangement of flow paths of working fluid to be supplied and drained by a fluid supply/drain apparatus and valves provided on the flow paths;

FIG. **7** is a schematic configuration diagram of a control device;

FIGS. **8**A, **8**B and **8**C are views showing the relation between travelling states of the ship and hull angles; and

FIG. **9** is a flowchart showing a procedure of target current determination processing performed by a target current determination unit.

## DESCRIPTION OF EMBODIMENT

Hereinafter, an embodiment of the present invention will be explained in detail with reference to the attached drawings.

FIGS. **1**A and **1**B are schematic structure views of a ship **1** according to the embodiment. FIG. **1**A is a view of the ship **1** seen from the above. FIG. **1**B is an enlarged view of a part "Ib" of FIG. **1**A. In the following explanation, a travelling direction of the ship **1** in a forward movement state is defined as a front direction, the left side of the travelling direction is defined as a left direction and the right side of the travelling direction is defined as a right direction.

The ship **1** includes a hull **2**, an annular steering wheel **3** rotatably attached to an instrument panel formed in a front part of a cabin **2***a* provided in the hull **2**, a remote-controller box **10** provided in a front-right part of the cabin **2***a* and a ship propulsion machine **20** generating propulsion.

The ship **1** also includes a hull angle sensor **4** arranged in the vicinity of the steering wheel **3** in the cabin **2***a*, outputting a signal corresponding to a hull angle θs as a tilt angle in a front and back direction of the hull **2** with respect to a horizontal surface. The hull angle sensor **4** has a pendulum (not shown) to which a magnet is attached, detecting a displacement from a vertical axis thereof by a reed switch (not shown) or the like and outputting a signal corresponding to the hull angle θs. As the hull angle sensor **4**, a sensor outputting a Lo signal when the hull angle θs is at a later described given angle θ0 or less and outputting a Hi signal when the hull angle θs is higher than the given angle θ0 can be cited as an example.

The remote-controller box **10** is provided with a tilt-angle adjustment switch **102** as an example of an operating unit configured to adjust a tilt angle θ (see FIG. **2**) of a ship propulsion machine body **20***a* of the ship propulsion machine **20** for the hull **2**, which will be described later.

Next, the ship propulsion machine **20** will be explained.

FIG. **2** is a schematic structure view of the ship propulsion machine **20**.

The ship propulsion machine **20** includes the ship propulsion machine body **20***a* generating propulsion and a tilt-angle adjusting apparatus **30** adjusting the tilt angle θ.

The ship propulsion machine body **20***a* has an engine (not shown) placed so that an axial direction of a crankshaft (not shown) is directed to a vertical direction (up and down direction) with respect to the water surface, a drive shaft (not shown) connected to a lower end of the crankshaft so as to be rotatable together and vertically extending downward, a propeller shaft **21** connected to the drive shaft through a bevel gear mechanism and a propeller **22** fixed to a back end of the propeller shaft **21**.

The ship propulsion machine body **20***a* has also a swivel shaft **23** (see FIG. **1**) provided in the vertical direction (up and down direction), a horizontal shaft **24** provided in a horizontal direction with respect to the water surface, a swivel case **25** in which the swivel shaft **23** is housed so as to swivel freely and a stern bracket **26** connecting the swivel case **25** to the hull **2**.

Next, the tilt-angle adjusting apparatus **30** will be explained.

The tilt-angle adjusting apparatus **30** includes a control device **100** controlling actuation of the tilt-angle adjusting apparatus **30**, a tilt angle sensor **101** detecting the tilt angle θ and a tilt-angle adjustment switch **102** (see FIG. **1**) for adjusting the tilt angle θ.

As the tilt angle sensor **101**, for example, an optical sensor detecting a distance between a back end portion of the hull **2** and the ship propulsion machine body **20***a* can be cited as an example. The tilt angle sensor **101** may have any structure which can detect a swivel angle of the swivel case **25** with respect to the stern bracket **26**.

The tilt-angle adjustment switch **102** is a seesaw switch which can be pressed at a left portion and a right portion. The tile angle θ is increased when the left portion (UP side) is pressed and the tile angle θ is decreased when the right portion (DOWN side) is pressed.

FIG. **3** is an outline view of the tilt-angle adjusting apparatus **30**. FIG. **4** is a cross-sectional view of a later-described cylinder apparatus and a pump chamber. FIG. **5** is a cross-sectional view of a later-described motor support portion.

The tilt-angle adjusting apparatus **30** has a cylinder apparatus **31** connected between the swivel case **25** and the bracket **26** extending and retracting for changing a distance therebetween and a fluid supply/drain apparatus **32** circulating working fluid for extending and retracting the cylinder apparatus **31**.

First, the cylinder apparatus **31** will be explained.

The cylinder apparatus **31** has a cylindrical portion and includes a housing **40** having a cylinder **41** with a bottomed cylindrical shape in which one end of the cylindrical portion in a center-line direction (up and down direction in FIG. **4**) is closed.

The center-line direction of the cylindrical portion of the cylinder **41** is referred to merely as the "center-line direction" in the following description.

The cylinder apparatus **31** has also a piston **42** inserted into the cylinder **41** so as to move in the center-line direction and a piston rod **43** extending in the center-line direction and to which the piston **42** is attached at one end (a lower end portion in FIG. **4**) in the center-line direction. The cylinder apparatus **31** further includes a nut **46** supporting the piston **42** with a male screw formed at one end of the piston rod **43**, a rod guide **44** arranged so as to close an opening on the other end side of the cylinder **41** and guiding the piston rod **43** and a cylindrical sleeve **45** for adjusting the stroke of the piston rod **43**.

The housing **40** includes the cylinder **41**, a later-described motor support portion **60** and a tank chamber **63** integrally. Moreover, flow paths as paths through which the working fluid flows are formed around the cylinder **41**, the motor support portion **60** and the tank chamber **63** as described later. At one end of the housing **40** in the center-line direction, a pin hole **40***a* supporting a pin for connecting the tilt-angle adjusting apparatus **30** to the stern bracket **26** is formed.

The piston **42** has a cylindrical piston body **42***a* in which a hole into which the piston rod **43** is inserted is formed at the center and a sealing member **42***b* such as an O-ring attached to an outer peripheral portion of the piston body **42***a*. On the outer peripheral portion of the piston body **42***a*, a groove **42***c* concave from an outer peripheral surface is formed over the entire circumference, and the sealing member **42***b* is fitted to the groove **42***c*. Then, the piston **42** touches an inner peripheral surface of the cylinder **41**, sectioning the space in the cylinder **41** in which the working fluid is sealed into a first oil chamber Y1 on one end side in the center-line direction with respect to the piston **42** and a second oil chamber Y2 on the other end side in the center-line direction with respect to the piston **42**.

The piston rod **43** has a cylindrical rod portion **43***a*, in which a male screw for attaching the piston **42** is formed at one end in the center-line direction and a pin hole **43***b* supporting a pin for connecting the piston rod **43** to the swivel case **25** is formed at the other end in the center-line direction.

The rod guide **44** includes an approximately cylindrical rod guide body **44***a* in which a hole into which the piston rod **43** is inserted is formed at the center, a sealing member **44***b* which is in sliding contact with the piston rod **43** at the center in the center-line direction and a water sealing **44***c* suppressing liquid such as water entering into the cylinder **41** at the other end in the center-line direction. A groove concave from an inner peripheral surface is formed in the inner periphery of the rod guide body **44***a*, and the sealing member **44***b* is fitted to the groove. Moreover, a concave portion concave from an end surface is formed at the other end of the rod guide body **44***a* in the center-line direction, and the water sealing **44***c* is fitted to the concave portion.

The sleeve **45** has a cylindrical shape, and an inner peripheral diameter thereof is smaller than an outer diameter of the piston body **42***a* of the piston **42**. Then, the sleeve **45** is arranged close to one end side of the cylinder **41** in the center-line direction, which restricts the movement of the piston **42** and the piston rod **43** toward one end side.

Next, the fluid supply/drain apparatus **32** will be explained.

The fluid supply/drain apparatus **32** includes a pump **61** supplying working fluid into the cylinder **41** of the cylinder apparatus **31**, a motor **62** driving the pump **61** and a motor support portion **60** supporting the motor **62**. The fluid supply/drain apparatus **32** has also a tank chamber **63** storing the working fluid to be supplied and drained with respect to the pump **61** and an oil supply plug **64** closing an opening of the tank chamber **63**.

The motor support portion **60** is provided in the above housing **40** so as to be adjacent to the cylinder **41** in a direction intersecting with the center-line direction. That is, the housing **40** has the cylinder **41** and the motor support **60** integrally. Then, the motor **62** is fixed to the other end side (an upper side in FIG. **4**) of the motor support portion **60** in the center-line direction by using a bolt. Also in the motor support portion **60**, a portion (a lower side in FIG. **4**) closer to one end side than the portion to which the motor **62** is fixed in the center-line direction is concave, and the concave portion forms a pump chamber **60***a* for housing the pump **61**. The pump chamber **60***a* houses working fluid as well as keeps the pump **61** in a state of being immersed in the working fluid.

The pump **61** is, for example, a gear pump having a cassette pump structure, having a gear unit including a drive gear and a driven gear in a case, which is fixed to the motor support portion **60** by a bolt **61***b* inside the pump chamber **60***a* so that a drive shaft **61***a* coupled to the drive gear is positioned to an output shaft **62***a* of the motor **62**. The pump **61** can be also rotated in both directions, connecting two discharge ports (not shown) for normal rotation and reverse rotation to the flow paths formed in the motor support portion **60** and opening two suction ports (not shown) for normal rotation and reverse rotation in the pump chamber **60***a*.

In the motor **62**, a yoke made of steel is attached to the motor support portion **60** by the bolt so that the motor **62** is positioned above the pump chamber **60***a*. The output shaft **62***a* of the motor **62** is connected to the drive shaft **61***a* of the pump **61** through a drive joint **62***b*, rotating in both directions.

The tank chamber **63** is provided so as to be adjacent to the cylinder **41** in the direction intersecting with the center-line direction. The motor support portion **60** communicates the tank chamber **63** to the pump chamber **60***a*.

Next, the flow paths for working fluid formed in the tilt-angle adjusting apparatus **30** will be explained.

In the tilt-angle adjusting apparatus **30**, a first flow path **71** communicating the first oil chamber Y1 to the pump chamber **60***a* and a second flow path **72** communicating the second oil chamber Y2 to the pump chamber **60***a* are formed.

The first flow path **71** includes an oil path **71***a* formed in the housing **40** closer to one end side (the lower side in FIG. **4**) rather than one end of the cylinder **41** in the center-line direction (the lower end portion in FIG. **4**), an oil path (not shown) formed in the motor support portion **60** closer to one end side (the lower side in FIG. **4**) in the center-line direction than the pump chamber **60***a* and so on.

The second flow path **72** includes, as shown in FIG. **4**, an oil path **72***a* formed in the housing **40** in the center-line direction so as to be adjacent to the cylinder **41**, an oil path **72***b* formed at the rod guide **44**, an oil path **72***c* formed in the cylinder **41** so as to communicate the oil path **72***a* to the oil path **72***b*, an oil path **72***d* formed in the motor support portion **60** closer to one end side (the lower side of FIG. **4**) in the center-line direction than the pump chamber **60***a* and so on.

FIG. **6** is a schematic diagram showing the arrangement of the flow paths of the working fluid to be supplied and drained by the fluid supply/drain apparatus **32** and valves provided on the flow paths.

The fluid supply/drain apparatus **32** includes a shuttle-type changeover valve **80**, non-return valves **91**, **92**, a retraction-side relief valve **93**, an extension-side relief valve **94** and a manual and thermal valve **95**.

The shuttle-type changeover valve **80** has a shuttle piston **81** and a first check valve **82***a* and a second check valve **82***b* arranged at both sides of the shuttle piston **81**. In the shuttle-type changeover valve **80**, a first shuttle chamber **83***a* is formed on the first check valve **82***a* side of the shuttle piston **81** and a second shuttle chamber **83***b* is formed on the second check valve **82***b* side of the shuttle piston **81**.

The first check valve **82***a* can be opened by oil feed pressure added to the first shuttle chamber **83***a* through a pipe line **99** by normal rotation of the pump **61**, and the second check valve **82***b* can be opened by oil feed pressure added to the second shuttle chamber **83***b* through the pipe line **99** by reverse rotation of the pump **61**. Additionally, the shuttle piston **81** can open the second check valve **82***b* by oil feed pressure by normal rotation of the pump **61** and can open the first check valve **82***a* by oil feed pressure by reverse rotation of the pump **61**. The first check valve **82***a* of the shuttle-type changeover valve **80** is connected to the first flow path **71** and the second check valve **82***b* is connected to the second flow path **72**.

The non-return valves **91** and **92** are each arranged at an intermediate part of a connection flow path between the pump **61** and the tank chamber **63**. The retraction-side relief valve is connected to the second flow path **72**, and the extension-side relief valve **94** is housed inside the shuttle piston **81**. The manual and thermal valve **95** is connected to the oil path **71***a* (see FIG. **4**) of the first flow path **71**, connecting the first oil chamber Y1 to the tank chamber **63**. The manual and thermal valve **95** includes a thermal relief valve **95***a*, relieving circuit pressure to the tank chamber **63** with a predetermined pressure when pressure of working fluid in the cylinder **41** is abnormally increased due to heat and so on.

Next, working of the tilt-angle adjusting apparatus **30** will be explained.

When the motor **62** is normally rotated to thereby normally rotate the pump **61**, discharged oil from the pump **61** opens the first check valve **82***a* of the shuttle-type changeover valve **80** as well as opens also the second check valve **82***b* through the shuttle piston **81**. Accordingly, the discharged oil from the pump **61** is supplied to the first oil chamber Y1 of the cylinder apparatus **31** through the first check valve **82***a* and the first flow path **71**, and working fluid of the second oil chamber Y2 of the cylinder apparatus **31** is returned to the pump **61** through the second flow path **72** and the second check valve **82***b* to thereby extend the cylinder apparatus **31**. As a result, the tilt angle θ (see FIG. **2**) is increased.

At the time of operation for increasing the tilt angle θ, the amount of circulating oil of working fluid will be short in supply as the volume of the cylinder **41** is increased by the withdrawal volume of the piston rod **43**, therefore, the non-return valve **92** opens and the shortfall of the circulating oil can be compensated to the pump **61** from the tank chamber **63**. Additionally, at the time of operation for increasing the tilt angle θ, in the case where the circuit pressure becomes higher than a predetermined pressure as the pump **61** keeps working after the piston **42** reaches the maximum extended position and the operation for increasing the tilt angle θ is completed, the extension-side relief valve **94** opens to thereby relieve the circuit pressure to the pump suction side.

On the other hand, when the motor is reversely rotated to thereby reversely rotate the pump **61**, discharged oil from the pump **61** opens the second check valve **82***b* of the shuttle-type changeover valve **80** as well as opens also the first check valve **82***a* through the shuttle piston **81**. Accordingly, the discharged oil from the pump **61** is supplied to the second oil chamber Y2 of the cylinder apparatus **31** through the second check valve **82***b* and the second flow path **72**, and working fluid of the first oil chamber Y1 of the cylinder apparatus **31** is returned to the pump **61** through the first flow path **71** and the first check valve **82***a* to thereby retract the cylinder apparatus **31**. As a result, the tilt angle θ (see FIG. **2**) is decreased.

At the time of operation for decreasing the tilt angle θ, the amount of circulating oil of working fluid will be excessive as the volume of the cylinder **41** is reduced by the approach volume of the piston rod **43**, therefore, the retraction-side relief valve **93** opens and the excessive amount of the circulating oil is returned to the tank chamber **63**. Additionally, when the pump **61** keeps working after the piston **42** reaches the maximum retraction position and the operation for decreasing the tilt angle θ is completed and there becomes no oil to be returned to the pump **61** from the first oil chamber Y1, the non-return valve **91** opens and working fluid can be supplied from the tank chamber **63**. Also in the case where the circuit pressure becomes higher than a predetermined pressure as the pump **61** keeps working after the operation for decreasing the tilt angle θ is completed, the retraction-side relief valve **93** opens to relieve the circuit pressure to the tank chamber **63**.

When the cylinder apparatus **31** is retracted manually, the manual and thermal valve **95** opens, therefore, the tilt angle θ can be decreased.

Next, the control device **100** will be explained.

FIG. **7** is a schematic configuration diagram of the control device **100**.

The control device **100** is an arithmetic logic circuit including a CPU, a ROM, a RAM, a backup RAM and so on. A hull angle signal obtained by converting the hull angle θs detected by the hull angle sensor **4** into an output signal, an "up" signal as a signal indicating that the left portion of the tilt-angle adjustment switch **102** has been pressed and a "down signal" as a signal indicating that the right portion of the tilt-angle adjustment switch **102** has been pressed are inputted to the control device **100**.

Then, the control device **100** includes a target current determination unit **110** determining a target current It to be supplied to the motor **62** of the tilt-angle adjusting apparatus **30** based on the hull angle signal, the "up" signal and the "down" signal and a controller **120** performing feedback control and the like based on the target current It determined by the target current determination unit **110**. As described above, the control device **100** functions as an example of a motor control unit configured to control the drive of the motor **62**. The target current determination unit **110** will be described later.

First, the controller **120** will be explained.

The controller **120** includes a motor drive controller **130** controlling actuation of the motor **62** of the tilt-angle adjusting apparatus **30**, a motor drive unit **140** driving the motor **62** and a motor current detector **150** detecting an actual current Im actually flowing in the motor **62**.

The motor drive controller **130** includes a feedback (F/B) controller **131** performing feedback control based on a deviation between the target current It determined by the target current determination unit **110** and the actual current Im detected by the motor current detector **150** and supplied to the motor **62**, and a PWM signal generator **132** generating a PWM (pulse width modulation) signal for performing PWM control to the motor **62**.

The motor drive unit **140** includes a motor drive circuit in which four field-effect transistors for electric power are connected in a configuration of an H-type bridge circuit and a gate drive circuit unit in which gates of two field-effect transistors selected from the four field-effect transistors are driven to allow these field-effect transistors to perform switching operation. The gate drive circuit unit controls the drive of the motor **62** by selecting two field-effect transistors and allowing the selected two field-effect transistors to perform switching operation based on the PWM signal (drive control signal) outputted from the PWM signal generator **132**.

The motor current detector **150** detects a value of the actual current Im flowing in the motor **62** from a voltage generated at both ends of a shunt resistance connected to the motor drive unit **140**.

Next, the target current determination unit **110** will be explained.

FIGS. **8**A to **8**C are views showing the relation between travelling states of the ship and hull angles. In FIGS. **8**A to **8**C, the front and back direction of the hull **2** is denoted by a sign "d", the water surface is denoted by a sign "s" and seawater or freshwater is denoted by a sign "w".

FIG. **8**A shows a state in which the ship **1** is stopped or travels at a relatively low speed. When the speed of the hull **2** is increased from the above state as the propulsion of the ship, propulsion machine **20** is accelerated, the hull **2** becomes in a state in which a stem **2***f* is lifted, whereas a stern **2***b* sinks as shown in FIG. **8**B. In this state, as the hull angle θs is higher than the later-described given angle θ0, the hull angle sensor **4** outputs a Hi signal.

After that, when the acceleration ends, the speed of the ship **1** becomes stable, the lifted stem **2***f* of the hull **2** comes down and the ship **1** becomes in a sliding state as shown in FIG. **8**C. When the ship **1** becomes in the sliding state, the hull angle θs is reduced to the given angle θ0 or less, therefore, the hull angle sensor **4** outputs a Lo signal.

Note that the given angle θ0 is set to a value whereby it is possible to determine that acceleration ends and the ship **1** is in the sliding state and, for example, 5 deg can be cited as an example.

When the hull angle θs detected by the hull angle sensor **4** is larger than the given angle θ0, the target current determination unit **110** determines a predetermined given current It0 as the target current It for controlling the drive of the motor **62** to increase the tilt angle θ. On the other hand, when the hull angle θs detected by the hull angle sensor **4** is smaller than the given angle θ0, the target current determination unit **110** determines a value (=−It0) obtained by multiplying the given current It0 by "−1" as the target current It for controlling the drive of the motor **62** to reduce the tilt angle θ. The target current determination unit **110** also determines "0" as the target current It when the hull angle θs detected by the hull angle sensor **4** is equal to the given angle θ0. Concerning the sign of the target current It, the direction in which the motor **62** is normally rotated is defined as a plus, and the direction in which the motor **62** is reversely rotated is defined as a minus. The given current It0 is a positive value.

However, the target current determination unit **110** determines the given current It0 in the direction allowing the motor **62** to normally rotate as the target current It for increasing the tilt angle θ in the case where the "up" signal as the signal indicating that the left portion of the tilt-angle adjustment switch **102** has been pressed even when the hull angle θs detected by the hull angle sensor **4** is different from the given angle θ0. Moreover, the target current determination unit **110** determines "−It0" in the direction allowing the motor **62** to reversely rotate as the target current It for decreasing the tilt angle θ in the case where the "down" signal as the signal indicating that the right portion of the tilt-angle adjustment switch **102** has been pressed even when the hull angle θs detected by the hull angle sensor **4** is different from the given angle θ0.

Next, a procedure of target current determination processing performed by the target current determination unit **110** will be explained with reference to a flowchart.

FIG. **9** is a flowchart showing the procedure of the target current determination processing performed by the target current determination unit **110**. The target current determination unit **110** executes the target current determination processing repeatedly in every predetermined period.

First, the target current determination unit **110** determines whether the "up" signal is acquired or not (S**901**). Then, when the "up" signal is acquired (YES in S**901**), the target current It is determined to be the given current It0 in the direction allowing the motor **62** to normally rotate (S**902**). On the other hand, when the "up" signal is not acquired (NO in S**901**), the target current determination unit **110** determines whether the "down" signal is acquired or not (S**903**). Then, when the "down" signal is acquired (YES in S**903**), the target current It is determined to be "−It0" in the direction allowing the motor **62** to reversely rotate (S**904**).

On the other hand, when the "down" signal is not acquired (NO in S**903**), whether the hull angle θs detected by the hull angle sensor **4** is the given angle θ0 or not is determined (S**905**). When the hull angle θ is not the given angle θ0 (NO in S**905**), whether the hull angle θs is larger than the given angle θ0 or not is determined (S**906**). Then, when the hull angle θs is larger than the given angle θ0 (YES in S**906**), the target current It is determined to be the given current It0 in the direction allowing the motor **62** to normally rotate (S**907**). On the other hand, when the hull angle θs is not larger than the given angle θ0 (NO in S**906**), it is assumed that the hull angle θs is smaller than the given angle θ0, therefore, the target current It is determined to be "−It0" in the direction of allowing the motor **62** to reversely rotate (S**908**).

On one hand, when the hull angle θs is equal to the given angle θ0, the target current It is determined to be "0" (S**909**).

In the tilt-angle adjusting apparatus **30** configured as the above, when the hull angle θs detected by the hull angle sensor **4** is not equal to the given angle θ0 in the case where the tilt-angle adjustment switch **102** is not pressed, the target current It to be supplied to the motor **62** is determined so that the hull angle θs is equal to the given angle θ0. As a result, the hull angle θs is adjusted to the given angle θ0 at which a good travelling state can be obtained. As described above, the hull angle θs is automatically adjusted with high accuracy so that the hull angle θs becomes the given angle θ0 as a good angle for travelling in the tilt-angle adjusting apparatus **30** according to the present embodiment. Accordingly, even a beginner of ship operation can keep the travelling posture of the ship **1** in a good condition.

In the tilt-angle adjusting apparatus **30** according to the embodiment, the above advantages are realized by the simple configuration in which electric current to be supplied to the motor **62** is changed so that the hull angle θs detected by the hull angle sensor **4** provided in the ship **1** becomes the given angle θ0.

Though the target current It is changed according to whether the hull angle θs is equal to the given angle θ0, smaller than the given angle θ0, or larger than the given angle θ0 in the above embodiment, the present invention is not limited to these examples. For example, the target current It may be changed according to whether the hull angle θs is within a given range around the given angle θ0, smaller than the given range or larger than the given range. That is, in the case where the tilt-angle adjustment switch **102** is not pressed, when the hull angle θs is within the given range around the given angle θ0, the target current It may be determined to be "0", when the hull angle θs is larger than the given range, the target current It may be determined to be It0 and when the hull angle θs is smaller than the given range, the target current It may be determined to be −It0. As the given range around the given angle θ0, a range of θ0±0.5 degrees can be cited as an example.

Furthermore, an absolute amount is the same in the target current It determined due to the fact that the tilt-angle adjustment switch **102** is pressed and the target current It determined due to the fact that the hull angle θs is different from the given angle θ0 in the above embodiment, however, the present invention is not limited to the example. For example, the absolute value of the target current It determined due to the fact that the tilt-angle adjustment switch **102** is pressed is set to a current higher than the given current It0. Accordingly, the change speed of the tilt angle θ in the case where the tilt-angle adjustment switch **102** is pressed can be higher than the case where the tilt angle θ is changed due to that fact that the hull angle θs is different from the given angle θ0.

What is claimed is:

**1**. A tilt-angle adjusting apparatus comprising:

a motor adjusting a tilt angle of a ship propulsion machine body with respect to a longitudinal axis of a hull; and

a motor control unit configured to control drive of the motor so as to change the tilt angle in accordance with an output from a detecting unit configured to detect a hull angle which is an angle of the hull with respect to a water surface, wherein

the motor control unit recognizes the hull angle based on a signal from the detecting unit that is provided at the hull to detect the hull angle, and controls drive of the motor so that the recognized hull angle becomes a given angle,

the motor control unit rotates the motor to one rotation direction so that the hull angle decreases when the hull angle is larger than the given angle, and rotates the motor to other rotation direction so that the hull angle increases when the hull angle is smaller than the given angle, and when the motor rotates in the one rotation direction, the tilt angle with respect to the longitudinal axis of the hull increases while the hull angle decreases, and when the motor rotates in the other rotational direction, the tilt angle with respect to the longitudinal axis of the hull decreases while the hull angle increases.

**2**. The tilt-angle adjusting apparatus according to claim **1**, further comprising:

an operating unit that is configured to adjust the tilt angle, wherein the motor control unit controls drive of the motor based on a signal outputted from the operating unit in case where the operating unit is operated even when the hull angle is different from the given angle.

**3**. A ship propulsion machine giving propulsion to a hull comprising:

a ship propulsion machine body including a propeller; and

a tilt-angle adjusting apparatus including a motor adjusting a tilt angle of the ship propulsion machine body with respect to a longitudinal axis of the hull, and a motor control unit configured to control drive of the motor so as to change the tilt angle in accordance with a hull angle which is an angle of the hull with respect to a water surface, wherein the motor control unit recognizes the hull angle based on a signal from the detecting unit that is provided at the hull to detect the hull angle, and controls drive of the motor so that the recognized hull angle becomes a given angle,

the motor control unit rotates the motor to one rotation direction so that the hull angle decreases when the hull angle is larger than the given angle, and rotates the motor to other rotation direction so that the hull angle increases when the hull angle is smaller than the given angle, and when the motor rotates in the one rotation direction, the tilt angle with respect to the longitudinal axis of the hull increases while the hull angle decreases, and when the motor rotates in the other rotational direction, the tilt angle with respect to the longitudinal axis of the hull decreases while the hull angle increases.

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